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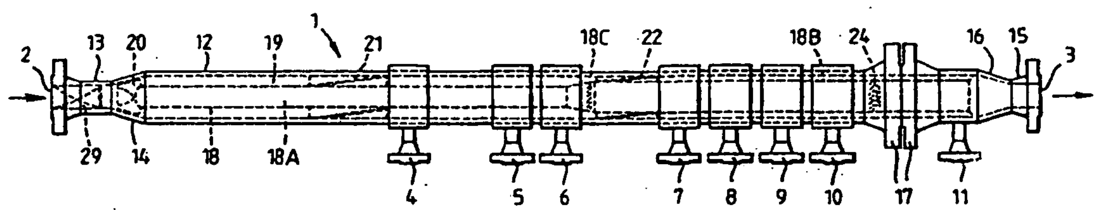
(54) Title: APPARATUS FOR SEPARATING AQUEOUS PHASE FROM A MIXTURE OF HYDROCARBON AND AQUEOUS FLUIDS



(57) Abstract

A separator (1) suitable for separating the aqueous phase from a mixture of hydrocarbon and aqueous fluids comprises an outer tube (12) which extends from an inlet (2) of the separator to the outlet (3) thereof. An inner tube (18) is mounted substantially coaxially within the outer tube to define an annular space (19) therebetween. Means are provided to direct fluid from the inlet end of said separator into the annular space to flow along the annular space towards the outlet end of the separator, and fins (21, 22, and 23) are located between the tubes for inducing spiral movement of the fluid flowing along said annular space. Apertures (23) in the inner tube permitting fluid to flow from said annular space into said inner tube, and a plurality of take-off points (4-11) along said outer tube are selectively openable to permit fluid adjacent the outer edge of the annular space to be removed from the annular space via an open take-off point.

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APPARATUS FOR SEPARATING AQUEOUS PHASE FROM A MIXTURE OF HYDROCARBON AND AQUEOUS FLUIDS

This invention relates to a separator for removing at least part of the aqueous phase from a mixture of hydrocarbon and aqueous fluids.

In many oil production installations the fluid emanating from the well comprises a mixture of hydrocarbon liquid, hydrocarbon gas, and aqueous liquid. The various components may exist in different ratios and in particular the mixture may include a continuous hydrocarbon phase or a continuous aqueous phase. A suitable separator must be employed for removing the aqueous phase prior to further treatment of the hydrocarbon phase.

For any given proportion of aqueous phase a separator can be designed to effect substantially complete separation of the aqueous phase from the hydrocarbon phase. However, known simple separator designs are only effective for a relatively narrow range of aqueous content on either side of the original design specification for which the separator was built. Separators can be designed which are capable of coping with a wide range of variations in the aqueous content of the material to be separated. However, such separators are large and complex with the result that they are both expensive to produce, difficult to transport to use positions, and occupy a large amount of space.

The present invention provides a relatively small separator which can be produced at a reasonable cost and

yet which is capable of removing substantially the entire aqueous content from a mixture of hydrocarbon and aqueous fluids over a relatively wide range of aqueous content in the input mixture.

According to one aspect of the present invention there is provided a separator comprising an outer tube which extends from the inlet end of the separator to the outlet end thereof; an inner tube mounted substantially co-axially within the outer tube to define an annular space therebetween; means for directing fluid from the inlet end of said separator into the annular space to flow along the annular space towards the outlet end of the separator; means for inducing spiral movement of the fluid flowing along said annular space; apertures in said inner tube permitting fluid to flow from said annular space into said inner tube; and a plurality of take-off points along said outer tube, said take-off points being selectively openable to permit fluid adjacent the outer edge of the annular space to be removed from the annular space via an open take-off point.

In use of the invention the take-off points which are opened, and the extent to which those take-off points are opened, is determined in light of the aqueous content of the inlet fluid and is adjusted such that the fluid flowing through the apertures into the inner tube is substantially free of aqueous phase. This fluid is removed from the outlet of the device for further processing. Similarly, the take-off points are adjusted such that the liquid removed via the take-off points has as small a hydrocarbon content as possible consistent with ensuring that the liquid flowing through the apertures is substantially free of aqueous phase. The fluid removed from the take-off points is then treated in a suitable device (for example a hydrocyclone device) to remove any small content of hydrocarbon liquid. The hydrocarbon

liquid so removed may be added to the output from the separator for further processing.

In a particularly preferred embodiment of the invention sensors are provided for determining the aqueous content of the inlet fluid and the take-off points are automatically adjusted, for example under computer control, in light of the input to produce the desired output characteristics. Additionally or alternatively the take-off points may be controlled in light of the aqueous content of the output from the separator and/or the aqueous content of the output from one or more of the take-off points. By this means, a substantially automatic system may be devised which is capable of achieving the desired substantially aqueous phase free output for a wide range of well output characteristics. Variations in the input due to changing characteristics of the well output can automatically be compensated for to ensure optimum output conditions.

The invention will be better understood from the following description of a preferred embodiment thereof, given by way of example only, reference being had to the accompanying drawings wherein:

Figure 1 shows schematically a separator according to the present invention;

Figures 2 and 3 show details of the construction of the separator of Figure 1; and

Figure 4 shows schematically how the separator of Figure 1 may be incorporated within a system for automatic control of the take-off points.

Referring firstly to Figure 1 the illustrated separating apparatus 1 extends from an inlet 2 into which is received a mixture of hydrocarbon and aqueous fluid to an outlet 3 for hydrocarbon fluid substantially free from aqueous phase. A multiplicity of take-off points 4-11 are located along the apparatus for removing the aqueous

phase.

The separator 1 comprises an outer tube 12 which is connected to the inlet section 13 of the separator via a tapering transition member 14. Similarly, the outer tube 12 is connected to the outlet section 15 by a tapering transition member 16. For convenience of manufacture and maintenance the outer tube is split adjacent the outlet end of the separator, the adjacent ends of the split tube being furnished with flange members 17 which are normally bolted together so that the tube 12 is substantially continuous between the transition members 14 and 16.

An inner tube 18 is located substantially co-axially within the outer tube to define an annular zone 19 between the inner and outer tubes. The inner tube includes a relatively small diameter portion 18A located towards the inlet end of the separator and a relatively large diameter portion 18B located towards the outlet end of the separator. The portions 18A,18B are interconnected by a transition member 18C. The end of the tube 18 adjacent the transition member 16 is welded to the outer tube 12 so that the annular space 19 is closed at the downstream end of the separator. The end of the tube 18 adjacent the transition member 14 is closed and the tube 18 is supported co-axially within the outer tube by fins 20,21 and 22 which are described in more detail hereinafter.

A multiplicity of apertures 23 are provided in the transition member 18C thereby allowing fluid to flow from the annular zone 19 to the interior of the inner tube 18. Similarly, a plurality of apertures 24 are provided in the inner tube 19 somewhat downstream of take-off point 10.

The structure of each take-off point 4-11 is substantially identical and is shown in greater detail in Figure 3. At each take-off point a multiplicity of holes 25 are formed in the wall of the outer tube. The holes 25

are interconnected with each other and with an outlet member 26 by a gallery 27 formed by a groove machined in the outer surface of the outer tube and a groove machined on the inner surface of a sleeve 28 which is welded to the outer tube. The outlet members are provided with control valves (not illustrated in Figure 1) which allow the degree of opening of each take-off point to be separately controlled. At least one vane 29 is located within the inlet section 13 of the separator.

In use, fluid comprising a mixture of aqueous and hydrocarbon phases enters the separator through the inlet section 13. Conveniently, the inlet section has the same diameter as the pipe feeding it and is approximately 3 diameters in length. As the fluid passes through the inlet section the vane 29 imparts an initial spin to the fluid.

The fluid to be treated passes through the transition member 14 into the annular space 19 between the inner and outer tubes. Vanes 20 located within the transition member 14 enhance the swirling action of the fluid as it passes into the annular space. As fluid flows along the annular space the vanes 21,22 maintain or enhance the swirling movement of the fluid. The vanes 20,21,22 are conveniently welded to the inner tube 18 and are a sliding fit within the outer tube. The vanes accordingly act to support the inner tube within the outer tube as well as provide the desired swirling movement to the fluid.

As the fluid flows through the annular space 19 towards the outlet end of the separator the liquid phase tends to migrate outwardly to lie against the inner wall of the outer tube 12. By appropriately controlling the outlets from take-off point 4,5 and 6 a proportion of the aqueous phase may be removed. When the flow encounters the transition member 18C at least part of the hydrocarbon phase which occupies the radially inner portion of the annular zone 19 will flow through the apertures 23 into the

interior of the inner tube. The remaining liquid proceeds along the relatively narrow annular zone between the inner tube portion 18B and the outer tube 12 and further aqueous phase is removed via the take-off points 7,8,9 and 10. The remaining hydrocarbon phase, substantially free of aqueous phase, flows radially inwardly through the apertures 24 to join the hydrocarbon which has already flowed through apertures 23 and the combined flow passes through the outlet section 15 for further processing. Grit contained in the inlet flow will tend to accumulate in the blind portion of the annular space between the apertures 24 and the transition member 16 and may be removed therefrom via the take-off 11.

Although the take-off points 4-11 may be furnished with manual controls which can manually be adjusted to provide the correct operating characteristics a particularly preferred embodiment of the invention is operated under computer control. This is illustrated schematically in Figure 4. A sensor 30 is provided for sensing the proportion of aqueous phase within the flow supplied to the separator. This information is conveyed to a computer 31 which pre-sets electrically operated valves 32 in accordance with information contained within the computer as to optimum valve settings for a particular aqueous content. By way of example, if the incoming fluid has a large proportion of water the valves controlling take-off points 4,5 and 6 will be opened to remove a large quantity of water through these take-off points. If the input flow has a relatively small aqueous content take-off points 4,5 and 6 may be closed or substantially closed to reduce the flow therethrough. Additional monitors 33,34 are provided to monitor the outlet through at least some of the take-off points. Whilst in the illustrated embodiment monitors are provided only in relation to take-off points 6 and 9 it will be appreciated that other of the take-off

points may be provided with monitors in addition to or as alternatives to those illustrated. Similarly, the output from the separator may be monitored for water content and the valves 32 adjusted accordingly.

Since the separator is required to produce substantially aqueous free hydrocarbon the valves 32 will in general be set to remove the entire aqueous phase. In order to achieve this some hydrocarbon may be removed in addition to the aqueous phase through the take-off points 4-10. In the circumstances, the outlet from the take-off points 4-10 is preferably fed to a secondary separation device, for example a hydrocyclone 35. Aqueous phase from the hydrocyclone can be disposed of as appropriate and the hydrocarbon phase from the hydrocyclone can be added to the output from the main separator for further treatment.

CLAIMS

1. A separator comprising an outer tube which extends from the inlet end of the separator to the outlet end thereof; an inner tube mounted substantially co-axially within the outer tube to define an annular space therebetween; means for directing fluid from the inlet end of said separator into the annular space to flow along the annular space towards the outlet end of the separator; means for inducing spiral movement of the fluid flowing along said annular space; apertures in said inner tube permitting fluid to flow from said annular space into said inner tube; and a plurality of take-off points along said outer tube, said take-off points being selectively openable to permit fluid adjacent the outer edge of the annular space to be removed from the annular space via an open take-off point.

2. A separator according to claim 1 wherein sensors are provided for determining the aqueous content of the inlet fluid and means are provided for automatically adjusting the take-off points in response to the sensors.

3. A separator according to claim 1 or claim 2 wherein means are provided for controlling the take-off points in light of the aqueous content of the output from the separator and/or the aqueous content of the output from one or more of the take-off points.

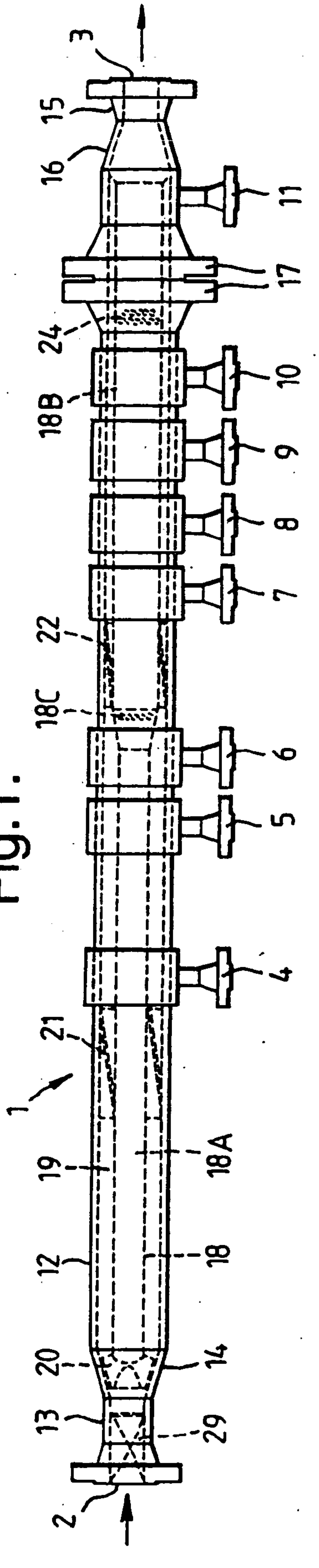

Fig.1.

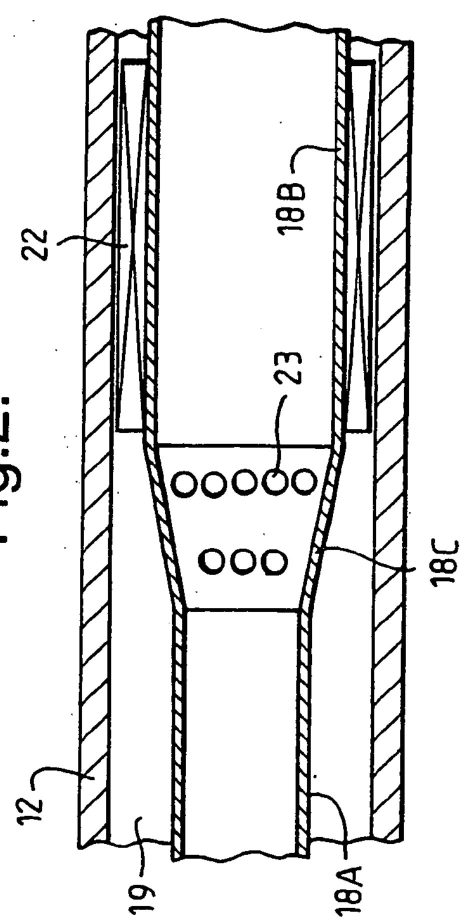

Fig.2.

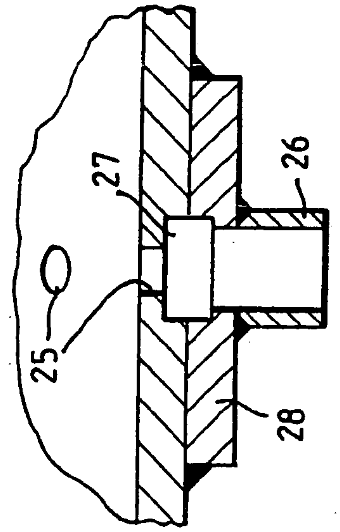

Fig.3.

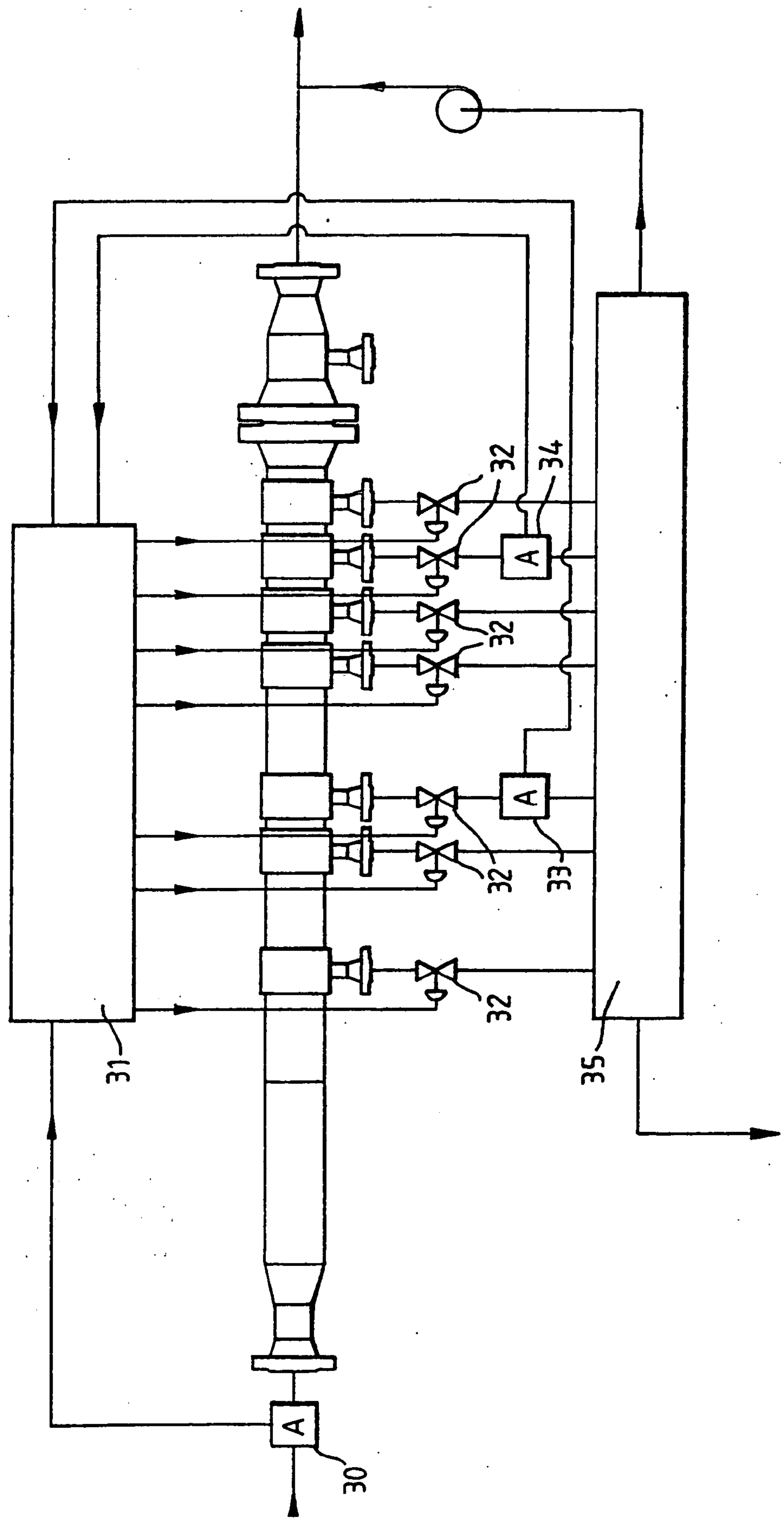

Fig.4.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 94/01699

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B01D17/02 B04C3/06 B04C11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B01D B04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NAVY TECHNICAL DISCLOSURE BULLETIN, vol.4, no.12, December 1979, ARLINGTON pages 21 - 25 J.S.GOLDSMITH 'total flow hydrocyclone separator' see the whole document	1
A	WO,A,90 02593 (SERCK BAKER LIMITED) 22 March 1990 see page 4, line 4 - line 38	1-3
A	EP,A,0 522 686 (KREBS ENGINEERS) 13 January 1993 see column 5, line 52 - column 6, line 53 see column 7, line 6 - line 14	1
A	DE,A,38 26 454 (LOREY,M.) 8 February 1990 see the whole document	1

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[X] Further documents are listed in the continuation of box C.

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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO,A,91 18655 (CHEVRON RESEARCH AND TECHNOLOGY) 12 December 1991 see page 8, line 32 - page 9, line 23 -----	1

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